I.28:SOLAR/1057-78/07

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SOLAR/1057-78/07

# Monthly Performance Report

ZEIN MECHANICAL

JULY 1978

## U.S. Department of Energy

### National Solar Heating and Cooling Demonstration Program

### National Solar Data Program

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MONTHLY PERFORMANCE REPORT
ZEIN MECHANICAL
JULY 1978

## I. SYSTEM DESCRIPTION

The Zein Mechanical site is a single family residence located in Milwaukee, Wisconsin. The home has two separate solar energy systems: an air system for space heating and cooling; a liquid system to preheat the potable hot water. The two systems are shown schematically in Figure 1

The space heating system, designated Zein Mechanical No. 1, is designed to supply approximately 44 percent of the space heating requirements for the 1,388 square foot residence. This system has a solar array of double-glazed acrylic collectors with a gross area of 384 square feet. The collectors, manufactured by Solaray, Inc., face south at an angle of 53 degrees from the horizontal. A fan circulates the solar heated air through the 412.5 cubic foot rock thermal storage, across the heat pump coil, then back to the inlet side of collectors. Thus, the solar heated air assists the heat pump in providing thermal energy to the heat exchanger in the air handler. Auxiliary space heating energy is supplied by 4-kw and 6-kw electric strip heaters. In the summer, the heat pump can also function in the cooling cycle to maintain desired temperatures in the conditioned space. The solar energy system components, heat pump compressor, evaporator, circulating fan, and rock thermal storage are located inside a sealed and insulated room in the house basement. Excessive heat buildup in the rock thermal storage is rejected to the ouside ambient either through back-draft damper D5, or through the collectors.

The liquid system, designated Zein Mechanical No. 2, uses distilled water as the transfer medium. This system has a solar array with a gross area of 77.6 square feet. The collectors, manufactured by Solarcraft, face south at an angle of 30 degrees from the horizontal. Solar heated water flows through the heat exchanger within the 82-gallon domestic hot water (DHW) heater to preheat the domestic hot water. Auxiliary energy for

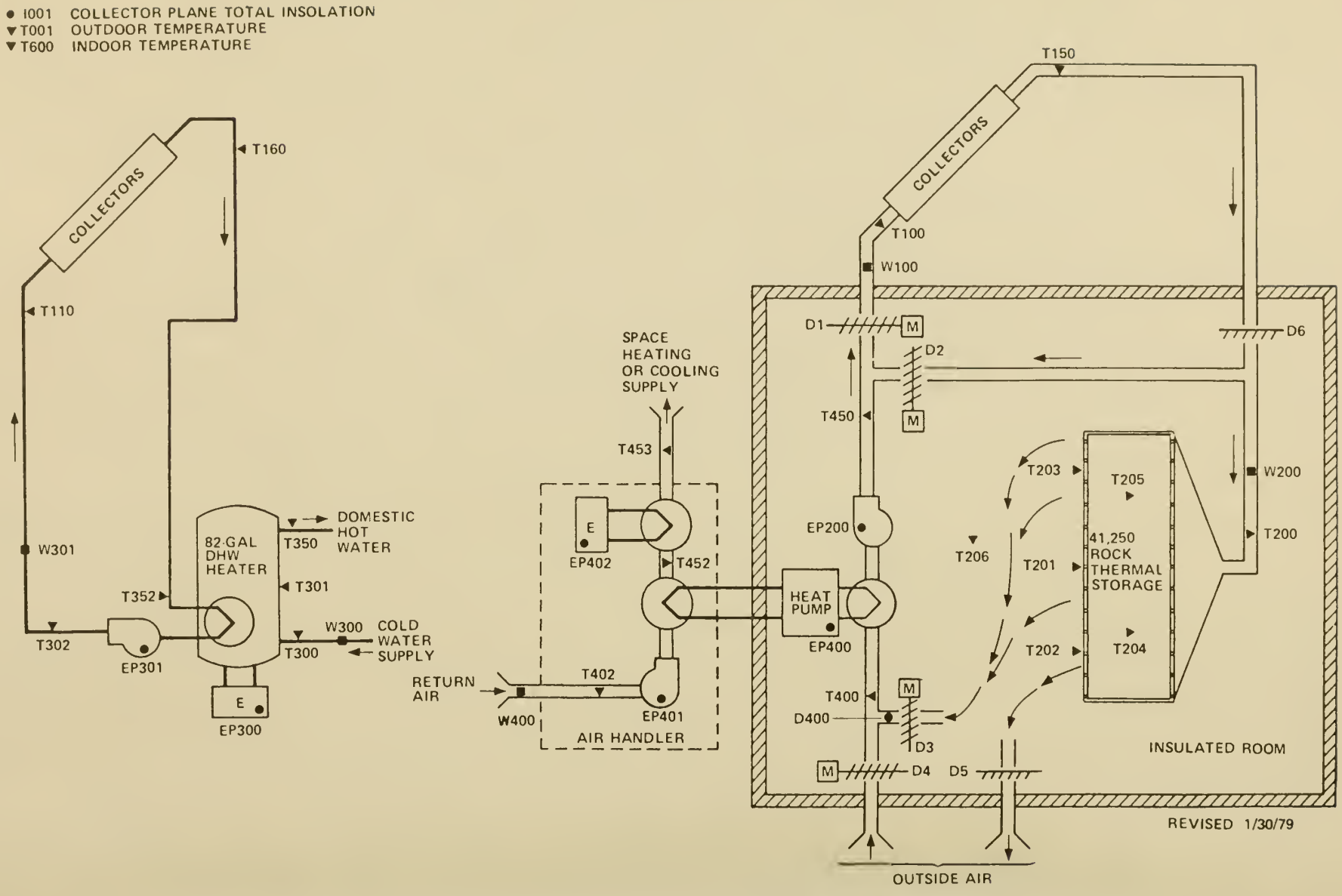


*Figure 1. ZEIN MECHANICAL SOLAR ENERGY SYSTEM SCHEMATIC*

hot water is provided by a 4.5-kw electric element in the DHW heater. For freeze protection, the DHW heater contains an interior chamber large enough to accommodate the collector loop distilled water when the system is not operating. The DHW system activates the collector pump to collect solar energy when the differential temperature between the collector outlet and the bottom of the hot water tank is greater than 10 degrees. When solar energy is unavailable, the pump deactivates to permit automatic draining.

The Zein Mechanical No. 1 system has five modes of heating and five modes of cooling. A matrix of operating modes, damper positions and mode control temperature sensor conditions is shown in Table 1.

Mode 1 - Storage-to-Space Heating: This winter mode is entered when there is a demand for space heating, the collector loop is not active, and the outside ambient temperature is less than 10°F above the rock thermal temperature. Air is drawn through motorized dampers from storage using the collector/heat pump circulating fan, past the heat pump evaporator coil, bypassing the collector, and back to storage. The heat pump condensor coil and house circulating fan supply energy to the house. Strip heaters supplement the heat pump to meet the heating demand.

Mode 2 - Collector-to-Storage: This winter mode is entered when the collector outlet temperature is 10°F higher than a temperature representative of storage, and the outside ambient temperature is less than 10°F above the rock thermal storage temperature. Air is drawn from the collector using the collector/heat pump circulating fan into the rock thermal storage through motorized dampers and recirculated through the collector. There may or may not be a demand for space heating.

Mode 3 - Outside Air-to-Storage (Heating): This mode is entered when the collector loop is inactive, there is no demand for space heating, and the outside ambient temperature is greater than 10°F above the rock thermal storage temperature. Air is drawn from the outside using the collector/heat pump circulating fan into the rock thermal storage through motorized dampers and then exhausted to the outside through a backdraft damper in the wall of the insulated room.

TABLE 1

Heating and Cooling Operating Mode Matrix

WINTER HEATING OPERATING MODE

| MODE | Tc-Tr $\geq$ 10°F | Ta-Tr $\geq$ 10°F | CALL FOR HEAT | FAN | DAMPER | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | D1 | D2 | D3 | D4 |
| OFF | NO | NO | NO | OFF | C | O | O | C |
| 1 | NO | NO | YES | ON | C | O | O | C |
| 2 | YES | NO | - | ON | O | C | O | C |
| 3 | NO | YES | NO | ON | C | O | C | O |
| 4 | NO | YES | YES | ON | C | O | C | O |
| 5 | YES | YES | - | ON | O | C | C | O |

SUMMER COOLING OPERATING MODE

| MODE | Tc-Tr $\leq$ -10°F | Ta-Tr $\leq$ -10°F | CALL FOR COOLING | FAN | DAMPER | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | D1 | D2 | D3 | D4 |
| OFF | NO | NO | NO | OFF | C | O | O | C |
| 6 | NO | NO | YES | ON | C | O | O | C |
| 7 | YES | NO | - | ON | O | C | O | C |
| 8 | NO | YES | NO | ON | C | O | C | O |
| 9 | NO | YES | YES | ON | C | O | C | O |
| 10 | YES | YES | - | ON | O | C | C | O |

MODE CONTROL TEMPERATURE SENSORS:

Tc - TEMPERATURE OF COLLECTORS

Ta - TEMPERATURE OF OUTSIDE AMBIENT AIR

Tr - TEMPERATURE OF ROCK STORAGE

Mode 4 - Outside Air-to-Space Heating: This winter mode is entered when there is a demand for space heating, the collector loop is not active, and the outside ambient temperature is greater than 10°F above the rock thermal storage temperature. Air is drawn from the outside through motorized dampers past the heat pump evaporator coil, through the rock thermal storage, and then exhausted to the outside through a backdraft damper in the wall of the insulated room. The heat pump condenser coil and house circulating fan supply energy to the house. Strip heaters supplement the heat pump to meet the heating demand.

Mode 5 - Outside Air-to-Collector (Heating): This mode is entered when the difference in temperature between the collector outlet temperature is 10°F higher than a temperature representative of storage, and the outside ambient temperature is greater than 10°F above the rock thermal storage temperature. Air is drawn from outside using the collector/heat pump circulating fan, through the collector, into the rock thermal storage through motorized dampers and then exhausted to the outside. There may or may not be a demand for space heating.

Mode 6 - Storage-to-Space Cooling: This summer mode is entered when there is a demand for space cooling, the collector loop is not active, and the storage temperature is less than 10°F above the outside ambient temperature. Air is drawn through motorized dampers from storage using the collector/heat pump fan, past the heat pump condenser coil, by-passing the collector, and back to storage. The heat pump evaporator coil and house circulating fan remove energy from the house.

Mode 7 - Collector Heat Rejection: This mode rejects storage energy by circulating air through the collectors at night. This summer mode is entered when the temperature of the storage is more than 10°F higher than the collector outlet temperature, and the storage temperature is less than 10°F above the outside ambient temperature. Air is drawn from the

collector at night using the collector/heat pump circulating fan into storage, through motorized dampers, and recirculated through the collector. There may or may not be a demand for space cooling.

Mode 8 - Storage Heat Rejection: This mode is entered when the collector loop is inactive, there is no demand for space cooling, and the rock thermal storage temperature is greater than 10°F above the outside ambient temperature. Air is drawn from the outside using the collector/heat pump circulating fan into the rock thermal storage, through motorized dampers, and then exhausted to the outside through a backdraft damper in the wall of the insulated room.

Mode 9 - Outside Air-to-Space Cooling: This summer mode is entered when there is a demand for space cooling, the coolector loop is not active, and the rock thermal storage temperature is greater than 10°F above the outside ambient temperature. Air is drawn from the outside through motorized dampers to the heat pump, past the heat pump condenser coil, through the rock thermal storage, and then exhausted to the outside through a backdraft damper in the wall of the insulated room. The heat pump evaporator coil and house circulating fan remove energy from the house to meet the cooling load.

Mode 10 - Outside Air-to-Collector (Cooling): This mode is entered when the temperature of the rock thermal storage is 10°F lower than the collector outlet temperature, and the rock thermal storage temperature is greater than 10°F above the outside ambient temperature. Air is drawn from outside through the collector using the collector/heat pump circulating fan, into the rock thermal storage, through motorized dampers, and then exhausted to the outside. There may or may not be a demand for space cooling.

## II. PERFORMANCE EVALUATION

### A. Introduction

The system performance evaluations discussed in this section are based primarily on the analysis of the data presented in the attached computer-generated monthly report. This attached report consists of daily site thermal and energy values for each subsystem, plus environmental data. The performance factors discussed in this report are based upon the definitions contained in NBSIR-76-1137, Thermal Data Requirements and Performance Evaluation Procedures for the National Solar Heating and Cooling Demonstration Program.

The Zein Mechanical site is an unoccupied model home. Because it is unoccupied, the house had a low space heating, space cooling, and hot water demand. The Zein Mechanical site operated only in the auxiliary cooling modes during July.

No space heating demand was predicted or measured during the month of July.

The water solar energy system satisfied 69 percent of the DHW demand of 0.02 million Btu with a resultant savings of 0.25 million Btu (74 kwh) of electrical energy.

The space cooling system was operated in the summer cooling Modes 6, 9, and 10, and in the rock bed energy rejection Modes 7 and 8. The space cooling system satisfied the space cooling demand of 0.85 million Btu using the heat pump auxiliary. The heat pump coefficient of performance was approximately 1.67, which is considerably less than the predicted performance of 2.5 for the heat pump in the cooling mode.

Although not part of the solar energy system, the space cooling system performance is indicated in the Extra Load Subsystem Report. Also, the heat pump space cooling performance is shown in the Auxiliary Thermodynamic Conversion Equipment Report. Refer to attached computer-generated printout for this cooling data.

B. Weather

The cloud cover in July was significantly above normal, as indicated by comparing the measured insolation with the predicted long-term monthly insolation. The insolation available on the solar energy system collector arrays during the month averaged 1,269 Btu/ft$^2$-day, which is significantly less than the 1,647 Btu/ft$^2$-day expected for the month. This is computed using an algorithm to estimate the insolation on a tilted surface from the long-term insolation data (on a horizontal surface) derived from measurements taken at the airport in Milwaukee, Wisconsin.

The measured ambient temperature was 69°F, which is 1°F lower than the 70°F predicted for July.

C. Space Heating System Thermal Performance

Collector - The collection system operated only to reject energy accumulated in storage due to operation of the heat pump in the cooling modes. No solar energy collection occurred.

Storage - No solar energy was collected or delivered to storage. However, operation of the space heating system actually provided 1.22 million Btu of evaporator cooling energy to the rock thermal storage.

Space Heating Load - During July, no space heating load was expected or measured. There were 15 heating degree-days measured at the site.

D. Domestic Hot Water Thermal Performance

Collector - Of the 3.05 million Btu of solar energy incident on the collector array during July, 0.76 million Btu were incident on the array when the collector circulating pump was operating. The system collected 0.39 million Btu, or 13 percent of the total insolation incident on the collector

array. The operation of the collector circulating pump required 0.03 million Btu of electrical energy. The collection subsystem was inactive during significant periods of the month.

Storage - Of the 0.76 million Btu of solar energy collected, 0.28 million Btu were delivered to storage. A total of 0.02 million Btu were extracted from storage and delivered to the space heating and domestic hot water demand. The storage thermal loss was 0.26 million Btu. The relatively high loss is due to the low consumption of hot water because the model home is unoccupied. Thermal loss from the transport system between the collector array and storage amounted to 0.48 million Btu, or 63 percent of the collected energy.

Domestic Hot Water Load - An average of one gallon of hot water was used each day and delivered at an average temperature of 136°F. The hot water was replaced with cold water at an average temperature of 63°F, which resulted in a hot water load of 0.02 million Btu. In order to satisfy this load and maintain domestic hot water average temperature at 136°F, 0.51 million Btu were supplied to the tank. Of the 0.51 million Btu supplied to the tank, 0.28 million Btu were supplied by solar energy and 0.23 million Btu were supplied by auxiliary electrical energy, resulting in a solar contribution to the load of 69 percent.

E. Space Cooling System

The space cooling demand was 0.85 million Btu, which was provided entirely by the heat pump. The space cooling load was significantly higher than expected for July due to having the control thermostat set at 70°F, and also to the requirement to remove uncontrolled energy lost from the insulated room containing the storage. The energy removed from the building during cooling was transferred to the rock bed. Thus, the storage temperature increased to near 100°F. The resultant losses from storage were transferred to the building. This rock bed/building interaction created the

larger-than-expected cooling load. In addition, the collector energy rejection mode was insufficient to remove enough energy to prevent the occurrence of this problem. The coefficient of performance of the heat pump in the cooling mode was 1.67 as compared to a predicted coefficient of 2.5 for this heat pump operating under the measured weather conditions.

F. Observations

The poor heat pump performance is probably due partially to the measurement inaccuracies of the air flow sensors at the site. The elimination of known duct leaks is necessary to obtain an accurate energy balance for the system. To identify the duct leaks, a duct flow survey would have to be completed at the inlet and outlet of each major subsystem and at the sensor locations.

Conditioned space cooling was provided entirely by the heat pump auxiliary. The space cooling load was significantly higher than expected for July. A considerable amount of energy was stored in the rock bed. The collector subsystem heat rejection mode was insufficient in removing rock bed heat. The resulting rock bed/insulated room losses added energy to the conditioned space, causing an increased cooling load. An analysis of the operation of the heat pump cooling modes should be undertaken. It would be desirable if the heat pump energy was rejected to the outside and not stored in storage when in cooling modes.

G. Energy Savings

The Zein Mechanical solar energy system for space heating was inoperative during the month of July. Thus, no savings were accrued.

The Zein Mechanical domestic hot water savings were 0.25 million Btu. The energy savings are based on the energy requirements of a conventional domestic hot water tank compared to the energy requirements of the solar energy system. The energy conversion efficiency from electrical to thermal energy was assumed to be 100 percent.

## III. ACTION STATUS

Minor instrumentation problems exist at the site. Site rework activity is necessary to survey air ducts to determine an accurate energy balance for the space heating system. Some temperature probes should be replaced.

A large air flow leak has been detected in the plenum system of the space heating collectors. The air leaks must be isolated and sealed in order for the system to perform to design specifications.

The data system experienced significant loss of data during the month. The collector outlet temperature was erratic - sometimes indicating properly, and other times, indicating a zero output.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: ZEIN MECHANICAL-I
REPORT PERIOD: JULY,1978

SOLAR/1057-78/07

SITE/SYSTEM DESCRIPTION:
THE ZEIN MECHANICAL - I SOLAR ENERGY SYSTEM UTILIZES A SOLAR ASSISTED HEAT PUMP TO HEAT AND COOL A 1389 SQ FT SINGLE FAMILY DWELLING. THE COLLECTION SUBSYSTEM CONSIST OF 384 SQ FT OF AIR COLLECTORS, TILTED AT 53 DEC., TO COLLECT SOLAR ENERGY DURING THE WINTER AND REJECT HEAT PUMP COOLING ENERGY DURING THE SUMMER. A 40 TON ROCK BED IS USED FOR STORAGE AUXILIARY HEATING IS SUPPLIED BY THE HEAT PUMP WHICH CONTAINS BOTH A 4 KW AND 6 KW ELECTRIC STRIP HEATER.

GENERAL SITE DATA:

| | | |
|---|---|---|
| INCIDENT SOLAR ENERGY | 15.107 | MILLION BTU |
| | 39341 | BTU/SQ.FT. |
| COLLECTED SOLAR ENERGY | 0.000 | MILLION BTU |
| | 0 | BTU/SQ.FT. |
| AVERAGE AMBIENT TEMPERATURE | 69 | DEGREES F |
| AVERAGE BUILDING TEMPERATURE | 75 | DEGREES F |
| ECSS SOLAR CONVERSION EFFICIENCY | 0.00 | |
| ECSS OPERATING ENERGY | 0.000 | MILLION BTU |
| TOTAL SYSTEM OPERATING ENERGY | 0.000 | MILLION BTU |
| TOTAL ENERGY CONSUMED | 0.000 | MILLION BTU |

SUBSYSTEM SUMMARY:

| | HOT WATER | HEATING | COOLING | SYSTEM TOTAL | |
|---|---|---|---|---|---|
| LOAD | N.A. | 0.000 | N.A. | 0.000 | MILLION BTU |
| SOLAR FRACTION | N.A. | 0 | N.A. | 0 | PERCENT |
| SOLAR ENERGY USED | N.A. | 0.000 | N.A. | 0.000 | MILLION BTU |
| OPERATING ENERGY | N.A. | 0.000 | N.A. | 0.000 | MILLION BTU |
| AUX. THERMAL ENERGY | N.A. | 0.000 | N.A. | 0.000 | MILLION BTU |
| AUX. ELECTRIC FUEL | N.A. | 0.000 | N.A. | 0.000 | MILLION BTU |
| AUX. FOSSIL FUEL | N.A. | N.A. | N.A. | N.A. | MILLION BTU |
| ELECTRICAL SAVINGS | N.A. | 0.000 | N.A. | 0.000 | MILLION BTU |
| FOSSIL SAVINGS | N.A. | N.A. | N.A. | N.A. | MILLION BTU |

SYSTEM PERFORMANCE FACTOR: 2.63

* DENOTES UNAVAILABLE DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28.1978. SOLAR/0004-78/18
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SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: ZEIN MECHANICAL-I
REPORT PERIOD: JULY,1978

SOLAR/1057-78/07

SITE/SYSTEM DESCRIPTION:
THE ZEIN MECHANICAL - I SOLAR ENERGY SYSTEM UTILIZES A SOLAR ASSISTED HEAT PUMP TO HEAT AND COOL A 1389 SQ FT SINGLE FAMILY DWELLING. THE COLLECTION SUBSYSTEM CONSIST OF 384 SQ FT OF AIR COLLECTORS, TILTED AT 53 DEG., TO COLLECT SOLAR ENERGY DURING THE WINTER AND REJECT HEAT PUMP COOLING ENERGY DURING THE SUMMER. A 40 TON ROCK BED IS USED FOR STORAGE AUXILIARY HEATING IS SUPPLIED BY THE HEAT PUMP WHICH CONTAINS BOTH A 4 KW AND 6 KW ELECTRIC STRIP HEATER.

GENERAL SITE DATA:

| | |
|---|---|
| INCIDENT SOLAR ENERGY | 15.937 GIGA JOULES |
| | 446759 KJ/SQ.M. |
| COLLECTED SOLAR ENERGY | 0.000 GIGA JOULES |
| | 0 KJ/SQ.M. |
| AVERAGE AMBIENT TEMPERATURE | 21 DEGREES C |
| AVERAGE BUILDING TEMPERATURE | 24 DEGREES C |
| ECSS SOLAR CONVERSION EFFICIENCY | 0.00 |
| ECSS OPERATING ENERGY | 0.000 GIGA JOULES |
| TOTAL SYSTEM OPERATING ENERGY | 0.000 GIGA JOULES |
| TOTAL ENERGY CONSUMED | 0.000 GIGA JOULES |

SUBSYSTEM SUMMARY:

| | HOT WATER | HEATING | COOLING | SYSTEM TOTAL |
|---|---|---|---|---|
| LOAD | N.A. | 0.000 | N.A. | 0.000 GIGA JOULES |
| SOLAR FRACTION | N.A. | 0 | N.A. | 0 PERCENT |
| SOLAR ENERGY USED | N.A. | 0.000 | N.A. | 0.000 GIGA JOULES |
| OPERATING ENERGY | N.A. | 0.000 | N.A. | 0.000 GIGA JOULES |
| AUX. THERMAL ENG | N.A. | 0.000 | N.A. | 0.000 GIGA JOULES |
| AUX. ELECTRIC FUEL | N.A. | 0.000 | N.A. | 0.000 GIGA JOULES |
| AUX. FOSSIL FUEL | N.A. | N.A. | N.A. | N.A. GIGA JOULES |
| ELECTRICAL SAVINGS | N.A. | 0.000 | N.A. | 0.000 GIGA JOULES |
| FOSSIL SAVINGS | N.A. | N.A. | N.A. | N.A. GIGA JOULES |

SYSTEM PERFORMANCE FACTOR: 2.63

* DENOTES UNAVAILABLE DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978. SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENERGY COLLECTION AND STORAGE SUBSYSTEM (ECSS)

SITE: ZEIN MECHANICAL-I
REPORT PERIOD: JULY,1978

SOLAR/1057-78/07

| DAY OF MONTH | INCIDENT SOLAR ENERGY MILLION BTU | AMBIENT TEMP DEG-F | ENERGY TO LOADS MILLION BTU | AUX THERMAL TO ECSS MILLION BTU | ECSS OPERATING ENERGY MILLION BTU | ECSS ENERGY REJECTED MILLION BTU | ECSS SOLAR CONVERSION EFFICIENCY |
|---|---|---|---|---|---|---|---|
| 1 | 0.126 | 64 | 0.000 | N | 0.000 | 0.000 | 0.000 |
| 2 | 0.043 | 59 | 0.000 | O | 0.000 | 0.000 | 0.000 |
| 3 | 0.491 | 65 | 0.000 | T | 0.000 | -0.006 | 0.000 |
| 4 | 0.684 | 69 | 0.000 | | 0.000 | -0.041 | 0.000 |
| 5 | * | * | * | A | * | * | * |
| 6 | 0.762 | 79 | 0.000 | P | 0.000 | -0.131 | 0.000 |
| 7 | * | * | * | P | * | * | * |
| 8 | * | * | * | L | * | * | * |
| 9 | 0.434 | 72 | 0.000 | I | 0.000 | 0.000 | 0.000 |
| 10 | 0.634 | 62 | 0.000 | C | 0.000 | 0.000 | 0.000 |
| 11 | 0.680 | 64 | 0.000 | A | 0.000 | 0.000 | 0.000 |
| 12 | 0.665 | 68 | 0.000 | B | 0.000 | 0.000 | 0.000 |
| 13 | 0.491 | 75 | 0.000 | L | 0.000 | 0.000 | 0.000 |
| 14 | 0.619 | 74 | 0.000 | E | 0.000 | 0.000 | 0.000 |
| 15 | 0.808 | 70 | 0.000 | | 0.000 | 0.000 | 0.000 |
| 16 | 0.582 | 66 | 0.000 | | 0.000 | 0.000 | 0.000 |
| 17 | 0.582 | 71 | 0.000 | | 0.000 | 0.315 | 0.000 |
| 18 | 0.319 | 79 | 0.000 | | 0.000 | 0.674 | 0.000 |
| 19 | 0.475 | 79 | 0.000 | | 0.000 | 0.258 | 0.000 |
| 20 | 0.193 | 72 | 0.000 | | 0.000 | 0.000 | 0.000 |
| 21 | 0.164 | 64 | 0.000 | | 0.000 | 0.273 | 0.000 |
| 22 | * | * | * | | * | * | * |
| 23 | * | * | * | | * | * | * |
| 24 | * | * | * | | * | * | * |
| 25 | 0.513 | 73 | 0.000 | | 0.000 | 0.000 | 0.000 |
| 26 | 0.161 | 73 | 0.000 | | 0.000 | 0.168 | 0.000 |
| 27 | 0.522 | 68 | 0.000 | | 0.000 | 0.030 | 0.000 |
| 28 | 0.592 | 68 | 0.000 | | 0.000 | 0.000 | 0.000 |
| 29 | 0.356 | 67 | 0.000 | | 0.000 | 0.000 | 0.000 |
| 30 | 0.611 | 62 | 0.000 | | 0.000 | 0.000 | 0.000 |
| 31 | 0.664 | 66 | 0.000 | | 0.000 | 0.000 | 0.000 |
| SUM | 15.107 | - | 0.000 | N.A. | 0.000 | 1.911 | - |
| AVG | 0.487 | 69 | 0.000 | N.A. | 0.000 | 0.061 | 0.000 |
| NBS ID | Q001 | N113 | | | Q102 | | N111 |

* DENOTES UNAVAILABLE DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
COLLECTOR ARRAY PERFORMANCE

SITE: ZEIN MECHANICAL-I
REPORT PERIOD: JULY,1978

SOLAR/1057-78/07

| DAY OF MONTH | INCIDENT SOLAR ENERGY MILLION BTU | OPERATIONAL INCIDENT ENERGY MILLION BTU | COLLECTED SOLAR ENERGY MILLION BTU | DAYTIME AMBIENT TEMP DEG F | COLLECTOR ARRAY EFFICIENCY |
|---|---|---|---|---|---|
| 1 | 0.126 | 0.000 | 0.000 | * | 0.000 |
| 2 | 0.043 | 0.000 | 0.000 | * | 0.000 |
| 3 | 0.491 | 0.000 | 0.000 | * | 0.000 |
| 4 | 0.684 | 0.000 | 0.000 | * | 0.000 |
| 5 | * | * | * | * | * |
| 6 | 0.762 | 0.000 | 0.000 | * | 0.000 |
| 7 | * | * | * | * | * |
| 8 | * | * | * | * | * |
| 9 | 0.434 | 0.000 | 0.000 | * | 0.000 |
| 10 | 0.634 | 0.000 | 0.000 | * | 0.000 |
| 11 | 0.680 | 0.000 | 0.000 | * | 0.000 |
| 12 | 0.665 | 0.000 | 0.000 | 77 | 0.000 |
| 13 | 0.491 | 0.000 | 0.000 | * | 0.000 |
| 14 | 0.619 | 0.000 | 0.000 | * | 0.000 |
| 15 | 0.808 | 0.000 | 0.000 | * | 0.000 |
| 16 | 0.582 | 0.000 | 0.000 | * | 0.000 |
| 17 | 0.582 | 0.000 | 0.000 | * | 0.000 |
| 18 | 0.319 | 0.000 | 0.000 | * | 0.000 |
| 19 | 0.475 | 0.000 | 0.000 | * | 0.000 |
| 20 | 0.193 | 0.000 | 0.000 | * | 0.000 |
| 21 | 0.164 | 0.000 | 0.000 | * | 0.000 |
| 22 | * | * | * | * | * |
| 23 | * | * | * | * | * |
| 24 | * | * | * | * | * |
| 25 | 0.513 | 0.000 | 0.000 | * | 0.000 |
| 26 | 0.161 | 0.000 | 0.000 | * | 0.000 |
| 27 | 0.522 | 0.000 | 0.000 | * | 0.000 |
| 28 | 0.592 | 0.000 | 0.000 | * | 0.000 |
| 29 | 0.356 | 0.000 | 0.000 | * | 0.000 |
| 30 | 0.611 | 0.000 | 0.000 | * | 0.000 |
| 31 | 0.664 | 0.000 | 0.000 | * | 0.000 |
| SUM | 15.107 | 0.000 | 0.000 | - | - |
| AVG | 0.487 | 0.000 | 0.000 | * | 0.000 |
| NBSID | Q001 | | Q100 | | N100 |

* DENOTES UNAVAILABLE DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
STORAGE PERFORMANCE

SITE:ZEIN MECHANICAL-I
REPORT PERIOD:JULY,1978

SOLAR/1057-78/07

| DAY OF MONTH | ENERGY TO STORAGE MILLION BTU | ENERGY FROM STORAGE MILLION BTU | CHANGE IN STORED ENERGY MILLION BTU | STORAGE AVERAGE TEMP DEG F | STORAGE EFFICIENCY |
|---|---|---|---|---|---|
| 1 | 0.017 | 0.000 | -0.007 | 86 | -0.400 |
| 2 | 0.000 | 0.000 | -0.038 | 82 | 1.000 |
| 3 | 0.059 | 0.000 | -0.010 | 79 | -0.183 |
| 4 | 0.130 | 0.000 | 0.054 | 81 | 0.418 |
| 5 | * | * | 0.057 | * | * |
| 6 | 0.243 | 0.000 | 0.103 | 95 | 0.423 |
| 7 | * | * | * | * | * |
| 8 | * | * | * | * | * |
| 9 | 0.000 | 0.000 | -0.058 | 97 | 1.000 |
| 10 | 0.000 | 0.000 | -0.049 | 90 | 1.000 |
| 11 | 0.000 | 0.000 | -0.035 | 85 | 1.000 |
| 12 | 0.000 | 0.000 | -0.023 | 81 | 1.000 |
| 13 | 0.000 | 0.000 | -0.011 | 79 | 1.000 |
| 14 | 0.000 | 0.000 | -0.009 | 78 | 1.000 |
| 15 | 0.000 | 0.000 | -0.005 | 77 | 1.000 |
| 16 | 0.000 | 0.000 | -0.007 | 76 | 1.000 |
| 17 | 0.145 | 0.000 | 0.077 | 77 | 0.533 |
| 18 | 0.228 | 0.000 | 0.111 | 92 | 0.488 |
| 19 | 0.049 | 0.000 | -0.008 | 100 | -0.165 |
| 20 | 0.000 | 0.000 | -0.042 | 97 | 1.000 |
| 21 | 0.053 | 0.000 | -0.045 | 91 | -0.857 |
| 22 | * | * | 0.118 | * | * |
| 23 | * | * | -0.049 | * | * |
| 24 | * | * | -0.096 | * | * |
| 25 | 0.000 | 0.000 | -0.004 | 85 | 1.000 |
| 26 | 0.047 | 0.000 | -0.015 | 83 | -0.329 |
| 27 | 0.009 | 0.000 | 0.008 | 83 | 0.924 |
| 28 | 0.000 | 0.000 | -0.013 | 83 | 1.000 |
| 29 | 0.000 | 0.000 | -0.009 | 81 | 1.000 |
| 30 | 0.000 | 0.000 | -0.011 | 80 | 1.000 |
| 31 | 0.000 | 0.000 | -0.011 | 78 | 1.000 |
| SUM | 1.221 | 0.000 | -0.037 | - | - |
| AVG | 0.039 | 0.000 | -0.001 | 85 | -0.031 |
| NBS ID | Q200 | Q201 | Q202 | | N108 |

* DENOTES UNAVAILABLE DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SPACE HEATING SUBSYSTEM

SITE: ZEIN MECHANICAL-I
REPORT PERIOD: JULY,1978

SOLAR/1057-78/07

| DAY OF MON. | SPACE HEATING LOAD MILLION BTU | SOLAR FR.OF LOAD PCT | SOLAR ENERGY USED MILLION BTU | OPER ENERGY MILLION BTU | AUX THERMAL USED MILLION BTU | AUX ELECT FUEL MILLION BTU | AUX FOSSIL FUEL MILLION BTU | ELECT ENERGY SAVINGS MILLION BTU | FOSSIL ENERGY SAVINGS MILLION BTU | BLDG TEMP DEG. F | AMB TEMP DEG. F |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.000 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | N | 0.000 | N | 70 | 64 |
| 2 | 0.000 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | O | 0.000 | O | 68 | 59 |
| 3 | 0.000 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | T | 0.000 | T | 68 | 65 |
| 4 | 0.000 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | | 0.000 | | 69 | 69 |
| 5 | * | * | * | * | * | * | A | * | A | * | * |
| 6 | 0.000 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | P | 0.000 | P | 70 | 79 |
| 7 | * | * | * | * | * | * | P | * | P | * | * |
| 8 | * | * | * | * | * | * | L | * | L | * | * |
| 9 | 0.000 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | I | 0.000 | I | 78 | 72 |
| 10 | 0.000 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | C | 0.000 | C | 78 | 62 |
| 11 | 0.000 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | A | 0.000 | A | 75 | 64 |
| 12 | 0.000 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | B | 0.000 | B | 74 | 68 |
| 13 | 0.000 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | L | 0.000 | L | 78 | 75 |
| 14 | 0.000 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | E | 0.000 | E | 80 | 74 |
| 15 | 0.000 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | | 0.000 | | 80 | 70 |
| 16 | 0.000 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | | 0.000 | | 73 | 66 |
| 17 | 0.000 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | | 0.000 | | 75 | 71 |
| 18 | 0.000 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | | 0.000 | | 73 | 79 |
| 19 | 0.000 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | | 0.000 | | 76 | 79 |
| 20 | 0.000 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | | 0.000 | | 80 | 72 |
| 21 | 0.000 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | | 0.000 | | 75 | 64 |
| 22 | * | * | * | * | * | * | | * | | * | * |
| 23 | * | * | * | * | * | * | | * | | * | * |
| 24 | * | * | * | * | * | * | | * | | * | * |
| 25 | 0.000 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | | 0.000 | | 77 | 73 |
| 26 | 0.000 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | | 0.000 | | 76 | 73 |
| 27 | 0.000 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | | 0.000 | | 76 | 68 |
| 28 | 0.000 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | | 0.000 | | 76 | 68 |
| 29 | 0.000 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | | 0.000 | | 77 | 67 |
| 30 | 0.000 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | | 0.000 | | 76 | 62 |
| 31 | 0.000 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | | 0.000 | | 76 | 66 |
| SUM | 0.000 | - | 0.000 | 0.000 | 0.000 | 0.000 | N.A. | 0.000 | N.A. | - | - |
| AVG | 0.000 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | N.A. | 0.000 | N.A. | 75 | 69 |
| NBS | Q402 | N400 | Q400 | Q403 | Q401 | | Q410 | Q415 | Q417 | N406 | N113 |

* DENOTES UNAVAILABLE DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENVIRONMENTAL SUMMARY

SITE:ZEIN MECHANICAL-I
REPORT PERIOD:JULY,1978

SOLAR/1057-78/07

| DAY OF MONTH | TOTAL INSOLATION BTU/SQ.FT | DIFFUSE INSOLATION BTU/SQ.FT | AMBIENT TEMPERATURE DEG F | DAYTIME AMBIENT TEMP DEG F | RELATIVE HUMIDITY PERCENT | WIND DIRECTION DEGREES | WIND SPEED M.P.H. |
|---|---|---|---|---|---|---|---|
| 1 | 329 | N | 64 | * | N | N | N |
| 2 | 112 | O | 59 | * | O | O | O |
| 3 | 1281 | T | 65 | * | T | T | T |
| 4 | 1782 | | 69 | * | | | |
| 5 | * | A | * | * | A | A | A |
| 6 | 1986 | P | 79 | * | P | P | P |
| 7 | * | P | * | * | P | P | P |
| 8 | * | L | * | * | L | L | L |
| 9 | 1132 | I | 72 | * | I | I | I |
| 10 | 1652 | C | 62 | * | C | C | C |
| 11 | 1773 | A | 64 | * | A | A | A |
| 12 | 1732 | B | 68 | 77 | B | B | B |
| 13 | 1279 | L | 75 | * | L | L | L |
| 14 | 1614 | E | 74 | * | E | E | E |
| 15 | 2105 | | 70 | * | | | |
| 16 | 1518 | | 66 | * | | | |
| 17 | 1517 | | 71 | * | | | |
| 18 | 832 | | 79 | * | | | |
| 19 | 1237 | | 79 | * | | | |
| 20 | 503 | | 72 | * | | | |
| 21 | 428 | | 64 | * | | | |
| 22 | * | | * | * | | | |
| 23 | * | | * | * | | | |
| 24 | * | | * | * | | | |
| 25 | 1336 | | 73 | * | | | |
| 26 | 422 | | 73 | * | | | |
| 27 | 1362 | | 68 | * | | | |
| 28 | 1542 | | 68 | * | | | |
| 29 | 930 | | 67 | * | | | |
| 30 | 1592 | | 62 | * | | | |
| 31 | 1730 | | 66 | * | | | |
| SUM | 39341 | N.A. | - | - | - | - | - |
| AVG | 1269 | N.A. | 69 | * | N.A. | N.A. | N.A. |
| NBS ID | Q001 | | N113 | | | N115 | N114 |

* DENOTES UNAVAILABLE DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
THERMODYNAMIC CONVERSION EQUIPMENT

SITE: ZEIN MECHANICAL-I
REPORT PERIOD: JULY,1978

SOLAR/1057-78/07
REPORT DATE: 08 MARCH 1979

| DAY OF MONTH | EQUIPMENT LOAD MILLION BTU | THERMAL ENERGY INPUT MILLION BTU | OPERATING ENERGY MILLION BTU | ENERGY REJECTED MILLION BTU | COEFFICIENT OF PERFORMANCE (SEE NOTE) |
|---|---|---|---|---|---|
| 1 | 0.000 | 0.000 | 0.000 | N | 0.000 |
| 2 | 0.000 | 0.000 | 0.000 | O | 0.000 |
| 3 | 0.000 | 0.000 | 0.000 | T | 0.000 |
| 4 | 0.000 | 0.000 | 0.000 | | 0.000 |
| 5 | * | * | * | A | * |
| 6 | 0.000 | 0.000 | 0.000 | P | 0.000 |
| 7 | * | * | * | P | * |
| 8 | * | * | * | L | * |
| 9 | 0.000 | 0.000 | 0.000 | I | 0.000 |
| 10 | 0.000 | 0.000 | 0.000 | C | 0.000 |
| 11 | 0.000 | 0.000 | 0.000 | A | 0.000 |
| 12 | 0.000 | 0.000 | 0.000 | B | 0.000 |
| 13 | 0.000 | 0.000 | 0.000 | L | 0.000 |
| 14 | 0.000 | 0.000 | 0.000 | E | 0.000 |
| 15 | 0.000 | 0.000 | 0.000 | | 0.000 |
| 16 | 0.000 | 0.000 | 0.000 | | 0.000 |
| 17 | 0.000 | 0.000 | 0.000 | | 0.000 |
| 18 | 0.000 | 0.000 | 0.000 | | 0.000 |
| 19 | 0.000 | 0.000 | 0.000 | | 0.000 |
| 20 | 0.000 | 0.000 | 0.000 | | 0.000 |
| 21 | 0.000 | 0.000 | 0.000 | | 0.000 |
| 22 | * | * | * | | * |
| 23 | * | * | * | | * |
| 24 | * | * | * | | * |
| 25 | 0.000 | 0.000 | 0.000 | | 0.000 |
| 26 | 0.000 | 0.000 | 0.000 | | 0.000 |
| 27 | 0.000 | 0.000 | 0.000 | | 0.000 |
| 28 | 0.000 | 0.000 | 0.000 | | 0.000 |
| 29 | 0.000 | 0.000 | 0.000 | | 0.000 |
| 30 | 0.000 | 0.000 | 0.000 | | 0.000 |
| 31 | 0.000 | 0.000 | 0.000 | | 0.000 |
| SUM | 0.000 | 0.000 | 0.000 | * | - |
| AVG | 0.000 | 0.000 | 0.000 | * | 0.000 |

* DENOTES UNAVAILABLE DATA.
NOTE:

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM
MONTHLY REPORT
EXTRA LOAD SUBSYSTEM

SITE:ZEIN MECHANICAL-I
REPORT PERIOD:JULY,1978

SOLAR/1057-78/07

| DAY OF MONTH | LOAD MILLION BTU | SOLAR FRACTION OF LOAD PERCENT | SOLAR ENERGY USED MILLION BTU | OPER ENERGY MILLION BTU | AUX THERMAL USED MILLION BTU | AUX ELECT FUEL MILLION BTU | AUX FOSSIL FUEL MILLION BTU | ELECT ENERGY SAVINGS MILLION BTU | FOSSIL ENERGY SAVINGS MILLION BTU |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.014 | N | N | 0.005 | 0.011 | 0.015 | N | N | N |
| 2 | 0.000 | O | O | 0.000 | 0.000 | 0.000 | O | O | O |
| 3 | 0.033 | T | T | 0.007 | 0.018 | 0.026 | T | T | T |
| 4 | 0.079 | | | 0.017 | 0.041 | 0.058 | | | |
| 5 | * | A | A | * | * | * | A | A | A |
| 6 | 0.176 | P | P | 0.039 | 0.101 | 0.145 | P | P | P |
| 7 | * | P | P | * | * | * | P | P | P |
| 8 | * | L | L | * | * | * | L | L | L |
| 9 | 0.000 | I | I | 0.000 | 0.000 | 0.000 | I | I | I |
| 10 | 0.000 | C | C | 0.000 | 0.000 | 0.000 | C | C | C |
| 11 | 0.000 | A | A | 0.000 | 0.000 | 0.000 | A | A | A |
| 12 | 0.000 | B | B | 0.000 | 0.000 | 0.000 | B | B | B |
| 13 | 0.000 | L | L | 0.000 | 0.000 | 0.000 | L | L | L |
| 14 | 0.000 | E | E | 0.000 | 0.000 | 0.000 | E | E | E |
| 15 | 0.000 | | | 0.000 | 0.000 | 0.000 | | | |
| 16 | 0.000 | | | 0.000 | 0.000 | 0.000 | | | |
| 17 | 0.068 | | | 0.015 | 0.038 | 0.054 | | | |
| 18 | 0.135 | | | 0.033 | 0.083 | 0.119 | | | |
| 19 | 0.052 | | | 0.015 | 0.037 | 0.054 | | | |
| 20 | 0.000 | | | 0.000 | 0.000 | 0.000 | | | |
| 21 | 0.079 | | | 0.020 | 0.047 | 0.067 | | | |
| 22 | * | | | * | * | * | | | |
| 23 | * | | | * | * | * | | | |
| 24 | * | | | * | * | * | | | |
| 25 | 0.000 | | | 0.000 | 0.000 | 0.000 | | | |
| 26 | 0.037 | | | 0.010 | 0.024 | 0.035 | | | |
| 27 | 0.004 | | | 0.001 | 0.003 | 0.005 | | | |
| 28 | 0.000 | | | 0.000 | 0.000 | 0.000 | | | |
| 29 | 0.000 | | | 0.000 | 0.000 | 0.000 | | | |
| 30 | 0.000 | | | 0.000 | 0.000 | 0.000 | | | |
| 31 | 0.000 | | | 0.000 | 0.000 | 0.000 | | | |
| SUM | 0.845 | - | N.A. | 0.205 | 0.505 | 0.722 | N.A. | N.A. | N.A. |
| AVG | 0.027 | N.A. | N.A. | 0.006 | 0.016 | 0.023 | N.A. | N.A. | N.A. |

* DENOTES UNAVAILABLE DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
AUXILIARY THERMODYNAMIC CONVERSION EQUIPMENT

SITE: ZEIN MECHANICAL-I SOLAR/1057-78/07
REPORT PERIOD: JULY,1978

| DAY OF MONTH | EQUIPMENT LOAD MILLION BTU | THERMAL ENERGY INPUT MILLION BTU | OPERATING ENERGY MILLION BTU | ENERGY REJECTED MILLION BTU | COEFFICIENT OF PERFORMANCE (SEE NOTE) |
|---|---|---|---|---|---|
| 1 | 0.014 | 0.015 | 0.002 | N | 1.284 |
| 2 | 0.000 | 0.000 | 0.000 | O | 0.000 |
| 3 | 0.033 | 0.026 | 0.004 | T | 1.820 |
| 4 | 0.079 | 0.058 | 0.009 | | 1.940 |
| 5 | * | * | * | A | * |
| 6 | 0.176 | 0.145 | 0.020 | P | 1.733 |
| 7 | * | * | * | P | * |
| 8 | * | * | * | L | * |
| 9 | 0.000 | 0.000 | 0.000 | I | 0.000 |
| 10 | 0.000 | 0.000 | 0.000 | C | 0.000 |
| 11 | 0.000 | 0.000 | 0.000 | A | 0.000 |
| 12 | 0.000 | 0.000 | 0.000 | B | 0.000 |
| 13 | 0.000 | 0.000 | 0.000 | L | 0.000 |
| 14 | 0.000 | 0.000 | 0.000 | E | 0.000 |
| 15 | 0.000 | 0.000 | 0.000 | | 0.000 |
| 16 | 0.000 | 0.000 | 0.000 | | 0.000 |
| 17 | 0.068 | 0.054 | 0.008 | | 1.811 |
| 18 | 0.135 | 0.119 | 0.017 | | 1.617 |
| 19 | 0.052 | 0.054 | 0.007 | | 1.387 |
| 20 | 0.000 | 0.000 | 0.000 | | 0.000 |
| 21 | 0.079 | 0.067 | 0.010 | | 1.682 |
| 22 | * | * | * | | * |
| 23 | * | * | * | | * |
| 24 | * | * | * | | * |
| 25 | 0.000 | 0.000 | 0.000 | | 0.000 |
| 26 | 0.037 | 0.035 | 0.005 | | 1.489 |
| 27 | 0.004 | 0.005 | 0.000 | | 1.224 |
| 28 | 0.000 | 0.000 | 0.000 | | 0.000 |
| 29 | 0.000 | 0.000 | 0.000 | | 0.000 |
| 30 | 0.000 | 0.000 | 0.000 | | 0.000 |
| 31 | 0.000 | 0.000 | 0.000 | | 0.000 |
| SUM | 0.845 | 0.722 | 0.107 | * | - |
| AVG | 0.027 | 0.023 | 0.003 | N.A. | 1.672 |

* DENOTES UNAVAILABLE DATA.
NOTE:

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: ZEIN MECHANICAL-II
REPORT PERIOD: JULY,1978

SOLAR/ 1057-78/07

SITE/SYSTEM DESCRIPTION:
THE ZEIN MECHANICAL-II SOLAR ENERGY SYSTEM HEATS DOMESTIC HOT WATER THROUGH THE USE OF 77.6 SQ FT OF LIQUID COLLECTORS AND AN 82 GALLON PREHEAT TANK. THE HOT WATER AUXILIARY IS A 4.5 KW ELECTRIC ELEMENT IN THE DHW TANK.

GENERAL SITE DATA:

| | |
|---|---|
| INCIDENT SOLAR ENERGY | 3.052 MILLION BTU |
| | 39341 BTU/SQ.FT. |
| COLLECTED SOLAR ENERGY | 0.390 MILLION BTU |
| | 5027 BTU/SQ.FT. |
| AVERAGE AMBIENT TEMPERATURE | 69 DEGREES F |
| AVERAGE BUILDING TEMPERATURE | N.A. DEGREES F |
| ECSS SOLAR CONVERSION EFFICIENCY | 0.09 |
| ECSS OPERATING ENERGY | 0.034 MILLION BTU |
| TOTAL SYSTEM OPERATING ENERGY | 0.034 MILLION BTU |
| TOTAL ENERGY CONSUMED | 0.661 MILLION BTU |

SUBSYSTEM SUMMARY:

| | HOT WATER | HEATING | COOLING | SYSTEM TOTAL |
|---|---|---|---|---|
| LOAD | 0.020 | N.A. | N.A. | 0.020 MILLION BTU |
| SOLAR FRACTION | 69 | N.A. | N.A. | 69 PERCENT |
| SOLAR ENERGY USED | 0.276 | N.A. | N.A. | 0.276 MILLION BTU |
| OPERATING ENERGY | N.A. | N.A. | N.A. | 0.034 MILLION BTU |
| AUX. THERMAL ENERGY | 0.234 | N.A. | N.A. | 0.234 MILLION BTU |
| AUX. ELECTRIC FUEL | 0.234 | N.A. | N.A. | 0.234 MILLION BTU |
| AUX. FOSSIL FUEL | N.A. | N.A. | N.A. | N.A. MILLION BTU |
| ELECTRICAL SAVINGS | 0.276 | N.A. | N.A. | 0.241 MILLION BTU |
| FOSSIL SAVINGS | N.A. | N.A. | N.A. | N.A. MILLION BTU |

SYSTEM PERFORMANCE FACTOR: 0.02

* DENOTES UNAVAILABLE DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT
OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978.
SOLAR/0004-78/18
READ THIS BEFORE TURNING PAGE

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: ZEIN MECHANICAL-II
REPORT PERIOD: JULY, 1978

SOLAR/1057-78/07

SITE/SYSTEM DESCRIPTION:
THE ZEIN MECHANICAL-II SOLAR ENERGY SYSTEM HEATS DOMESTIC HOT WATER THROUGH THE USE OF 77.6 SQ FT OF LIQUID COLLECTORS AND AN 82 GALLON PREHEAT TANK. THE HOT WATER AUXILIARY IS A 4.5 KW ELECTRIC ELEMENT IN THE DHW TANK.

GENERAL SITE DATA:

| | | |
|---|---|---|
| INCIDENT SOLAR ENERGY | 3.220 | GIGA JOULES |
| | 446759 | KJ/SQ.M. |
| COLLECTED SOLAR ENERGY | 0.411 | GIGA JOULES |
| | 57091 | KJ/SQ.M. |
| AVERAGE AMBIENT TEMPERATURE | 21 | DEGREES C |
| AVERAGE BUILDING TEMPERATURE | N.A. | DEGREES C |
| ECSS SOLAR CONVERSION EFFICIENCY | 0.09 | |
| ECSS OPERATING ENERGY | 0.036 | GIGA JOULES |
| TOTAL SYSTEM OPERATING ENERGY | 0.036 | GIGA JOULES |
| TOTAL ENERGY CONSUMED | 0.697 | GIGA JOULES |

SUBSYSTEM SUMMARY:

| | HOT WATER | HEATING | COOLING | SYSTEM TOTAL |
|---|---|---|---|---|
| LOAD | 0.022 | N.A. | N.A. | 0.022 GIGA JOULES |
| SOLAR FRACTION | 69 | N.A. | N.A. | 69 PERCENT |
| SOLAR ENERGY USED | 0.291 | N.A. | N.A. | 0.291 GIGA JOULES |
| OPERATING ENERGY | N.A. | N.A. | N.A. | 0.036 GIGA JOULES |
| AUX. THERMAL ENG | 0.247 | N.A. | N.A. | 0.247 GIGA JOULES |
| AUX. ELECTRIC FUEL | 0.247 | N.A. | N.A. | 0.247 GIGA JOULES |
| AUX. FOSSIL FUEL | N.A. | N.A. | N.A. | N.A. GIGA JOULES |
| ELECTRICAL SAVINGS | 0.291 | N.A. | N.A. | 0.254 GIGA JOULES |
| FOSSIL SAVINGS | N.A. | N.A. | N.A. | N.A. GIGA JOULES |

SYSTEM PERFORMANCE FACTOR: 0.02

* DENOTES UNAVAILABLE DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM, FEBRUARY 28, 1978, SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENERGY COLLECTION AND STORAGE SUBSYSTEM (ECSS)

SITE: ZEIN MECHANICAL-II
REPORT PERIOD: JULY,1978

SOLAR/1057-78/07

| DAY OF MONTH | INCIDENT SOLAR ENERGY MILLION BTU | AMBIENT TEMP DEG-F | ENERGY TO LOADS MILLION BTU | AUX THERMAL TO ECSS MILLION BTU | ECSS OPERATING ENERGY MILLION BTU | ECSS ENERGY REJECTED MILLION BTU | ECSS SOLAR CONVERSION EFFICIENCY |
|---|---|---|---|---|---|---|---|
| 1 | 0.025 | 64 | 0.000 | 0.013 | 0.000 | N | 0.000 |
| 2 | 0.008 | 59 | 0.000 | 0.013 | 0.000 | O | 0.000 |
| 3 | 0.099 | 65 | 0.006 | 0.007 | 0.002 | T | 0.062 |
| 4 | 0.138 | 69 | 0.009 | 0.000 | 0.001 | | 0.067 |
| 5 | * | * | * | * | * | A | * |
| 6 | 0.154 | 79 | 0.019 | 0.000 | 0.001 | P | 0.124 |
| 7 | * | * | * | * | * | P | * |
| 8 | * | * | * | * | * | L | * |
| 9 | 0.087 | 72 | 0.005 | 0.000 | 0.000 | I | 0.068 |
| 10 | 0.128 | 62 | 0.021 | 0.034 | 0.003 | C | 0.166 |
| 11 | 0.137 | 64 | 0.009 | 0.007 | 0.002 | A | 0.070 |
| 12 | 0.134 | 68 | 0.013 | 0.009 | 0.000 | B | 0.102 |
| 13 | 0.099 | 75 | -0.008 | 0.000 | 0.000 | L | -0.090 |
| 14 | 0.125 | 74 | 0.015 | 0.000 | 0.001 | E | 0.124 |
| 15 | 0.163 | 70 | 0.021 | 0.010 | 0.001 | | 0.132 |
| 16 | 0.117 | 66 | 0.004 | 0.000 | 0.000 | | 0.040 |
| 17 | 0.117 | 71 | 0.021 | 0.000 | 0.002 | | 0.186 |
| 18 | 0.064 | 79 | 0.010 | 0.032 | 0.002 | | 0.161 |
| 19 | 0.096 | 79 | 0.008 | 0.000 | 0.001 | | 0.093 |
| 20 | 0.039 | 72 | 0.000 | 0.010 | 0.000 | | 0.000 |
| 21 | 0.033 | 64 | 0.000 | 0.008 | 0.000 | | 0.000 |
| 22 | * | * | * | * | * | | * |
| 23 | * | * | * | * | * | | * |
| 24 | * | * | * | * | * | | * |
| 25 | 0.103 | 73 | 0.000 | 0.005 | 0.000 | | 0.000 |
| 26 | 0.032 | 73 | 0.000 | 0.000 | 0.000 | | 0.000 |
| 27 | 0.105 | 68 | 0.021 | 0.007 | 0.002 | | 0.205 |
| 28 | 0.119 | 68 | 0.003 | 0.000 | 0.000 | | 0.025 |
| 29 | 0.072 | 67 | 0.006 | 0.000 | 0.000 | | 0.094 |
| 30 | 0.123 | 62 | 0.020 | 0.019 | 0.002 | | 0.164 |
| 31 | 0.134 | 66 | 0.011 | 0.000 | 0.000 | | 0.085 |
| SUM | 3.052 | - | 0.276 | 0.234 | 0.034 | N.A. | - |
| AVG | 0.098 | 69 | 0.008 | 0.007 | 0.001 | N.A. | 0.090 |
| NBS ID | Q001 | N113 | | | Q102 | | N111 |

* DENOTES UNAVAILABLE DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
COLLECTOR ARRAY PERFORMANCE

SITE: ZEIN MECHANICAL-II
REPORT PERIOD: JULY,1978

SOLAR/1057 -78/07

| DAY OF MONTH | INCIDENT SOLAR ENERGY MILLION BTU | OPERATIONAL INCIDENT ENERGY MILLION BTU | COLLECTED SOLAR ENERGY MILLION BTU | DAYTIME AMBIENT TEMP DEG F | COLLECTOR ARRAY EFFICIENCY |
|---|---|---|---|---|---|
| 1 | 0.025 | 0.000 | 0.000 | * | 0.000 |
| 2 | 0.008 | 0.000 | 0.000 | * | 0.000 |
| 3 | 0.099 | 0.045 | 0.021 | * | 0.213 |
| 4 | 0.138 | 0.047 | 0.023 | * | 0.168 |
| 5 | * | * | * | * | * |
| 6 | 0.154 | 0.035 | 0.022 | * | 0.145 |
| 7 | * | * | * | * | * |
| 8 | * | * | * | * | * |
| 9 | 0.087 | 0.006 | 0.007 | * | 0.088 |
| 10 | 0.128 | 0.068 | 0.041 | * | 0.323 |
| 11 | 0.137 | 0.047 | 0.014 | * | 0.106 |
| 12 | 0.134 | 0.016 | 0.019 | 77 | 0.147 |
| 13 | 0.099 | 0.019 | 0.000 | * | 0.009 |
| 14 | 0.125 | 0.036 | 0.015 | * | 0.124 |
| 15 | 0.163 | 0.042 | 0.028 | * | 0.176 |
| 16 | 0.117 | 0.022 | 0.006 | * | 0.058 |
| 17 | 0.117 | 0.049 | 0.021 | * | 0.186 |
| 18 | 0.064 | 0.012 | 0.014 | * | 0.225 |
| 19 | 0.096 | 0.027 | 0.012 | * | 0.133 |
| 20 | 0.039 | 0.000 | 0.000 | * | 0.000 |
| 21 | 0.033 | 0.000 | 0.000 | * | 0.000 |
| 22 | * | * | * | * | * |
| 23 | * | * | * | * | * |
| 24 | * | * | * | * | * |
| 25 | 0.103 | 0.000 | 0.000 | * | 0.000 |
| 26 | 0.032 | 0.000 | 0.000 | * | 0.000 |
| 27 | 0.105 | 0.044 | 0.026 | * | 0.251 |
| 28 | 0.119 | 0.014 | 0.002 | * | 0.019 |
| 29 | 0.072 | 0.007 | 0.005 | * | 0.075 |
| 30 | 0.123 | 0.056 | 0.019 | * | 0.155 |
| 31 | 0.134 | 0.010 | 0.009 | * | 0.074 |
| SUM | 3.052 | 0.758 | 0.390 | - | - |
| AVG | 0.098 | 0.024 | 0.012 | * | 0.128 |
| NBSID | Q001 | | Q100 | | N100 |

* DENOTES UNAVAILABLE DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
STORAGE PERFORMANCE

SITE: ZEIN MECHANICAL-II
REPORT PERIOD: JULY, 1978

SOLAR/1057-78/07

| DAY OF MONTH | ENERGY TO STORAGE MILLION BTU | ENERGY FROM STORAGE MILLION BTU | CHANGE IN STORED ENERGY MILLION BTU | STORAGE AVERAGE TEMP DEG F | STORAGE EFFICIENCY |
|---|---|---|---|---|---|
| 1 | 0.000 | 0.000 | N | N | N |
| 2 | 0.000 | 0.000 | O | O | O |
| 3 | 0.006 | 0.000 | T | T | T |
| 4 | 0.009 | 0.000 | | | |
| 5 | * | * | A | A | A |
| 6 | 0.019 | 0.001 | P | P | P |
| 7 | * | * | P | P | P |
| 8 | * | * | L | L | L |
| 9 | 0.005 | 0.000 | I | I | I |
| 10 | 0.021 | 0.000 | C | C | C |
| 11 | 0.009 | 0.000 | A | A | A |
| 12 | 0.013 | 0.000 | B | B | B |
| 13 | -0.008 | 0.000 | L | L | L |
| 14 | 0.015 | 0.000 | E | E | E |
| 15 | 0.021 | 0.000 | | | |
| 16 | 0.004 | 0.000 | | | |
| 17 | 0.021 | 0.005 | | | |
| 18 | 0.010 | 0.000 | | | |
| 19 | 0.008 | 0.000 | | | |
| 20 | 0.000 | 0.000 | | | |
| 21 | 0.000 | * | | | |
| 22 | * | * | | | |
| 23 | * | * | | | |
| 24 | * | * | | | |
| 25 | 0.000 | 0.000 | | | |
| 26 | 0.000 | * | | | |
| 27 | 0.021 | 0.000 | | | |
| 28 | 0.003 | 0.000 | | | |
| 29 | 0.006 | 0.000 | | | |
| 30 | 0.020 | 0.009 | | | |
| 31 | 0.011 | 0.000 | | | |
| SUM | 0.276 | 0.020 | N.A. | - | - |
| AVG | 0.008 | 0.000 | * | N.A. | N.A. |
| NBS ID | Q200 | Q201 | Q202 | | N108 |

* DENOTES UNAVAILABLE DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
HOT WATER SUBSYSTEM

SITE: ZEIN MECHANICAL-II
REPORT PERIOD: JULY, 1978

SOLAR/1057 -78/07

| DAY OF MON. | HOT WATER LOAD MILLION BTU | SOLAR FR. OF LOAD PER. | SOLAR ENERGY USED MILLION BTU | OPER ENERGY MILLION BTU | AUX THERMAL USED MILLION BTU | AUX ELECT FUEL MILLION BTU | AUX FOSSIL FUEL MILLION BTU | ELECT ENERGY SAVINGS MILLION BTU | FOSSIL ENERGY SAVINGS MILLION BTU | SUP. WAT. TEMP DEG F | HOT WAT. TEMP DEG F | HOT WATER USED GAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.000 | 0 | 0.000 | N | 0.013 | 0.013 | N | 0.000 | N | 70 | 140 | 0 |
| 2 | 0.000 | 0 | 0.000 | O | 0.013 | 0.013 | O | 0.000 | O | 70 | 140 | 0 |
| 3 | 0.000 | 0 | 0.006 | T | 0.007 | 0.007 | T | 0.006 | T | 70 | 140 | 0 |
| 4 | 0.000 | 0 | 0.009 | | 0.000 | 0.000 | | 0.009 | | 70 | 140 | 0 |
| 5 | * | * | * | A | * | * | A | * | A | * | * | * |
| 6 | 0.001 | 62 | 0.019 | P | 0.000 | 0.000 | P | 0.019 | P | 64 | 138 | 2 |
| 7 | * | * | * | P | * | * | P | * | P | * | * | * |
| 8 | * | * | * | L | * | * | L | * | L | * | * | * |
| 9 | 0.000 | 0 | 0.005 | I | 0.000 | 0.000 | I | 0.005 | I | 59 | 137 | 0 |
| 10 | 0.000 | 0 | 0.021 | C | 0.034 | 0.034 | C | 0.021 | C | 59 | 137 | 0 |
| 11 | 0.000 | 0 | 0.009 | A | 0.007 | 0.007 | A | 0.009 | A | 59 | 137 | 0 |
| 12 | 0.000 | 0 | 0.013 | B | 0.009 | 0.009 | B | 0.013 | B | 59 | 137 | 0 |
| 13 | 0.000 | 0 | -0.008 | L | 0.000 | 0.000 | L | -0.008 | L | 59 | 137 | 0 |
| 14 | 0.000 | 0 | 0.015 | E | 0.000 | 0.000 | E | 0.015 | E | 59 | 137 | 0 |
| 15 | 0.000 | 0 | 0.021 | | 0.010 | 0.010 | | 0.021 | | 59 | 137 | 0 |
| 16 | 0.000 | 0 | 0.004 | | 0.000 | 0.000 | | 0.004 | | 59 | 137 | 0 |
| 17 | 0.005 | 100 | 0.021 | | 0.000 | 0.000 | | 0.021 | | 59 | 137 | 8 |
| 18 | 0.000 | 0 | 0.010 | | 0.032 | 0.032 | | 0.010 | | 60 | 137 | 0 |
| 19 | 0.000 | 0 | 0.008 | | 0.000 | 0.000 | | 0.008 | | 60 | 137 | 0 |
| 20 | 0.000 | 0 | 0.000 | | 0.010 | 0.010 | | 0.000 | | 60 | 137 | 0 |
| 21 | * | * | 0.000 | | 0.008 | 0.008 | | 0.000 | | * | * | * |
| 22 | * | * | * | | * | * | | * | | * | * | * |
| 23 | * | * | * | | * | * | | * | | * | * | * |
| 24 | * | * | * | | * | * | | * | | * | * | * |
| 25 | 0.000 | 0 | 0.000 | | 0.005 | 0.005 | | 0.000 | | 65 | 125 | 0 |
| 26 | * | * | 0.000 | | 0.000 | 0.000 | | 0.000 | | * | * | * |
| 27 | 0.000 | 0 | 0.021 | | 0.007 | 0.007 | | 0.021 | | 65 | 125 | 0 |
| 28 | 0.000 | 0 | 0.003 | | 0.000 | 0.000 | | 0.003 | | 65 | 125 | 0 |
| 29 | 0.000 | 0 | 0.006 | | 0.000 | 0.000 | | 0.006 | | 65 | 125 | 0 |
| 30 | 0.009 | 53 | 0.020 | | 0.019 | 0.019 | | 0.020 | | 62 | 135 | 14 |
| 31 | 0.000 | 0 | 0.011 | | 0.000 | 0.000 | | 0.011 | | 60 | 139 | 0 |
| SUM | 0.020 | - | 0.276 | N.A. | 0.234 | 0.234 | N.A. | 0.276 | N.A. | - | - | 32 |
| AVG | 0.000 | 69 | 0.008 | N.A. | 0.007 | 0.007 | N.A. | 0.008 | N.A. | 63 | 136 | 1 |
| NBS | Q302 | N300 | Q300 | Q303 | Q301 | Q305 | Q306 | Q311 | Q313 | N305 | N307 | N308 |

* DENOTES UNAVAILABLE DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENVIRONMENTAL SUMMARY

SITE: ZEIN MECHANICAL-II
REPORT PERIOD: JULY, 1978

SOLAR/1057-78/07

| DAY OF MONTH | TOTAL INSOLATION BTU/SQ.FT | DIFFUSE INSOLATION BTU/SQ.FT | AMBIENT TEMPERATURE DEG F | DAYTIME AMBIENT TEMP DEG F | RELATIVE HUMIDITY PERCENT | WIND DIRECTION DEGREES | WIND SPEED M.P.H. |
|---|---|---|---|---|---|---|---|
| 1 | 329 | N | 64 | * | N | N | N |
| 2 | 112 | O | 59 | * | O | O | O |
| 3 | 1281 | T | 65 | * | T | T | T |
| 4 | 1782 | | 69 | * | | | |
| 5 | * | A | * | * | A | A | A |
| 6 | 1986 | P | 79 | * | P | P | P |
| 7 | * | P | * | * | P | P | P |
| 8 | * | L | * | * | L | L | L |
| 9 | 1132 | I | 72 | * | I | I | I |
| 10 | 1652 | C | 62 | * | C | C | C |
| 11 | 1773 | A | 64 | * | A | A | A |
| 12 | 1732 | B | 68 | 77 | B | B | B |
| 13 | 1279 | L | 75 | * | L | L | L |
| 14 | 1614 | E | 74 | * | E | E | E |
| 15 | 2105 | | 70 | * | | | |
| 16 | 1518 | | 66 | * | | | |
| 17 | 1517 | | 71 | * | | | |
| 18 | 832 | | 79 | * | | | |
| 19 | 1237 | | 79 | * | | | |
| 20 | 503 | | 72 | * | | | |
| 21 | 428 | | 64 | * | | | |
| 22 | * | | * | * | | | |
| 23 | * | | * | * | | | |
| 24 | * | | * | * | | | |
| 25 | 1336 | | 73 | * | | | |
| 26 | 422 | | 73 | * | | | |
| 27 | 1362 | | 68 | * | | | |
| 28 | 1542 | | 68 | * | | | |
| 29 | 930 | | 67 | * | | | |
| 30 | 1592 | | 62 | * | | | |
| 31 | 1730 | | 66 | * | | | |
| SUM | 39341 | N.A. | - | - | - | - | - |
| AVG | 1269 | N.A. | 69 | * | N.A. | N.A. | N.A. |
| NBS ID | Q001 | | N113 | | | N115 | N114 |

* DENOTES UNAVAILABLE DATA.
N.A. DENOTES NOT APPLICABLE DATA.

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3 1262 09052 4793